Contents lists available at ScienceDirect

Polymer Testing

Property Modelling

Nonisothermal crystallization behavior and kinetics of isotactic polypropylene/ethylene–octene blends. Part II: Modeling of crystallization kinetics

Huamin Zhou [a,*], Jiru Ying [b], Xiaolin Xie [c], Fen Liu [a], Dequn Li [a]

[a] State Key Laboratory of Materials Processing and Mold Technology, Huazhong University of Science and Technology, Wuhan 430074, China
[b] Department of Chemical and Environment Engineering, Hubei University of Technology, Wuhan 430068, China
[c] Department of Chemistry and Chemical Engineering, Huazhong University of Science and Technology, Wuhan 430074, China

ARTICLE INFO

ABSTRACT

By applying the experimental data described in Part I, the non-isothermal crystallization kinetics of isotactic polypropylene/ethylene–octene blends have been mathematically modeled. The commonly used Avrami, Ozawa, Mo and Urbanovici–Segal models were used to model the crystallization kinetics, and it appears that Mo and Urbanovici–Segal models can well describe the non-isothermal crystallization kinetics of PP/POE blends. The data processing indicates that a small amount of POE can enhance the kinetic crystallizability because of heterogeneous nucleation, but excessive POE would in turn reduce the kinetic crystallizability by blocking the crystallization of PP.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

It is well known that the characteristics (mechanical, optical, electrical, transport and chemical) of polymeric products are to a great extent affected by the morphology formed during processing. Therefore, more and more studies of polymer processing (e.g., injection molding) not only consider the thermo-mechanical history of the process, but also take the crystallization into account [1–7]. The first step in the prediction of the crystallization distribution within processing is obviously the modeling of crystallization kinetics.

The study of non-isothermal crystallization kinetics of polymer started 30 years ago, bringing a dozen methods and models [8]. The earliest model for crystallization kinetics (Avrami) is based on a constant temperature, ignoring the thermal history that has a significant impact on the crystallization rate of the polymer. Later models (e.g., Ozawa model) consider the temperature changes in the crystallization process. Their parameters can be obtained through simple isothermal kinetics and slow cooling DSC experiments. Currently, there is still no satisfactory theoretical approach for non-isothermal crystallization kinetics. However, the existing models can characterize the temperature-dependence of crystallization rate, at least in form. At the present time, the only route to successfully address the problem of crystallization in polymer processing is to obtain fully characterized sets of data on a material and select a suitable model for characterization, modeling and simulation.

Based on the experimental data in Part I of this two-part paper, the present study focuses on the modeling of crystallization kinetics. The commonly used models were compared in detail, so as to improve the description of experimental data and find which model is the most suitable.

2. Data processing

Based on the experimental data of non-isothermal crystallization under atmospheric pressure (in Part I), the

---

* Corresponding author. Tel: +86 27 87543492; fax: +86 27 87554405.
E-mail address: hmzhou@hust.edu.cn (H. Zhou).

relative crystallinity can be obtained at any crystallization temperature, as shown in Fig. 1 for PP and its blends. The figure demonstrates that the curves at different cooling rates are very similar. With increasing cooling rate, the crystallization temperature shifts toward lower temperature; with increasing POE content at the same cooling rate, the crystallization temperature shifts toward

higher temperature. This suggests that POE plays a role of heterogeneous nuclei in the crystallization of PP. For the non-isothermal crystallization process at a constant cooling rate, the curve of relative crystallinity vs. temperature (as shown in Fig. 1) can be transferred into the curve of relative crystallinity vs. time (as shown in Fig. 2).
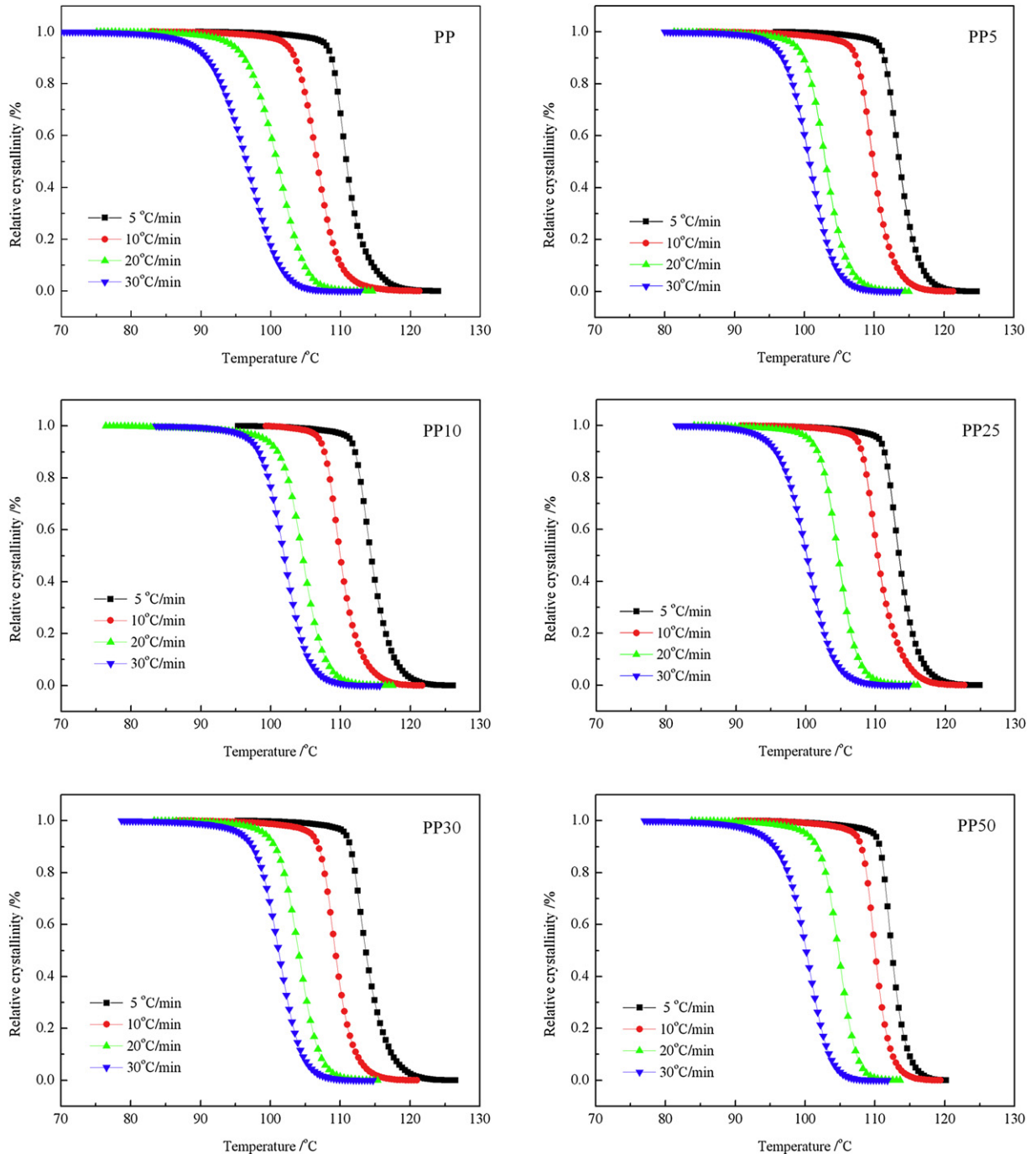

Fig. 1. Relationship between the relative crystallinity and temperature for PP and its blends.